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(54) Mechanically engaged four-wheel-drive vehicle using recirculating ball screw and nut actuation

(57) A vehicle comprises two drive wheels (4) and two normally-driven wheels (6) mounted in an idling manner on the ends of axle shafts (9) which are connected to a differential assembly (8). The latter is connected to an engine-transmission assembly (3) via a propeller shaft (10) and a first disengageable coupling (11). A second disengageable coupling (12) is located between each driven wheel (6) and its associated axle shaft (9). Each disengageable coupling (11, 12) is operated between engaged and disengaged positions by means of a control device featuring an electromechanical linear actuator with a recirculating ball screw-nut screw coupling.

The actuator may comprise an electric motor driving the nut of the coupling via reduction gearing, which in turn drives a rod linearly to engage or disengage the drive coupling (11) via a rocker arm. A microswitch may be provided adjacent the rocker arm to detect the engaged/disengaged positions.

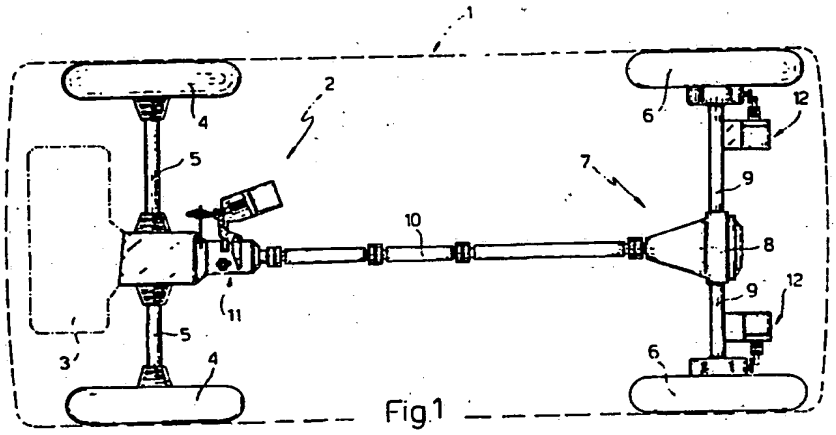

Fig.1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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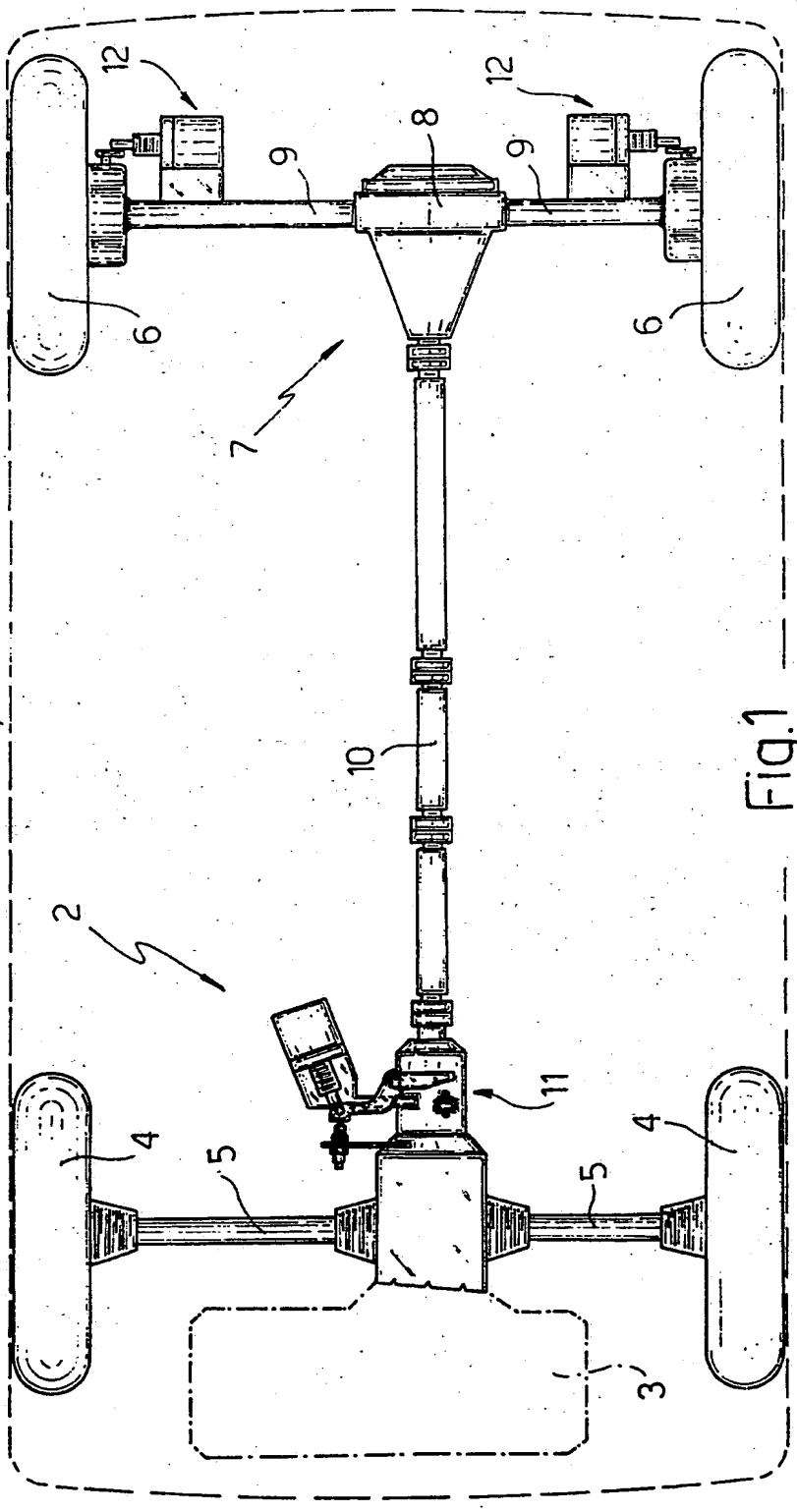
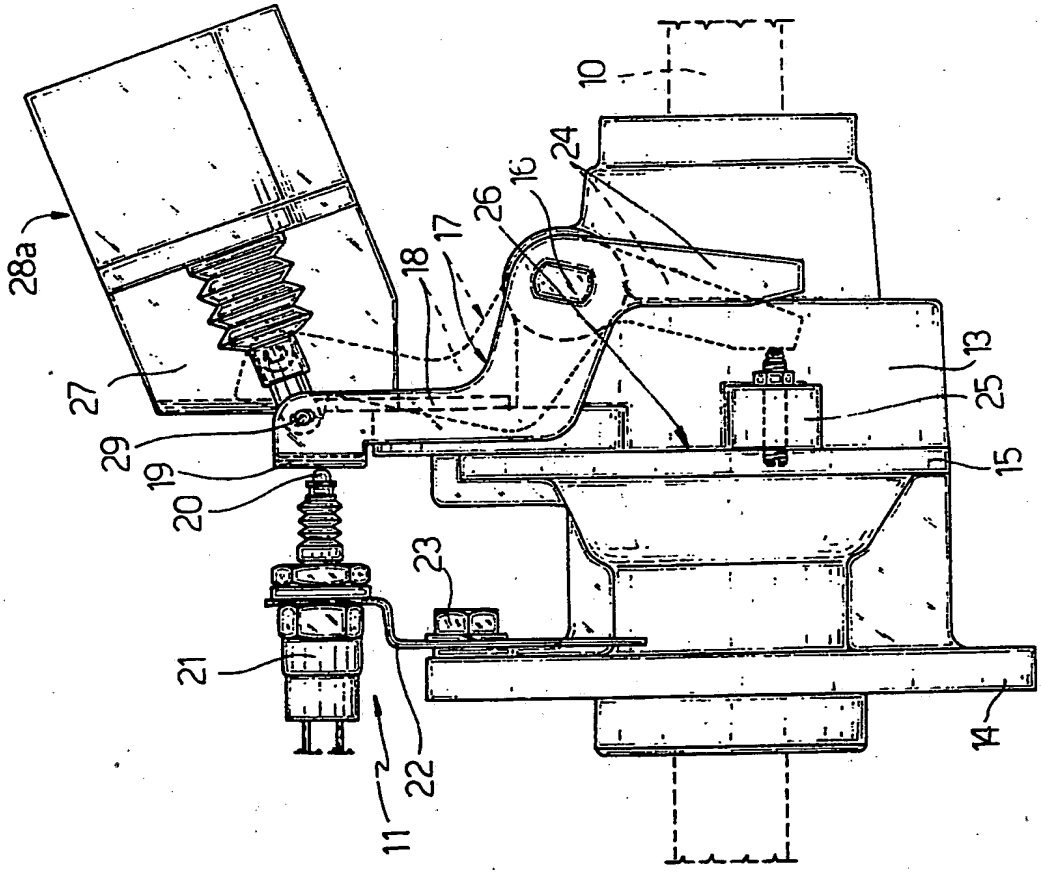


Fig.1

Fig.2



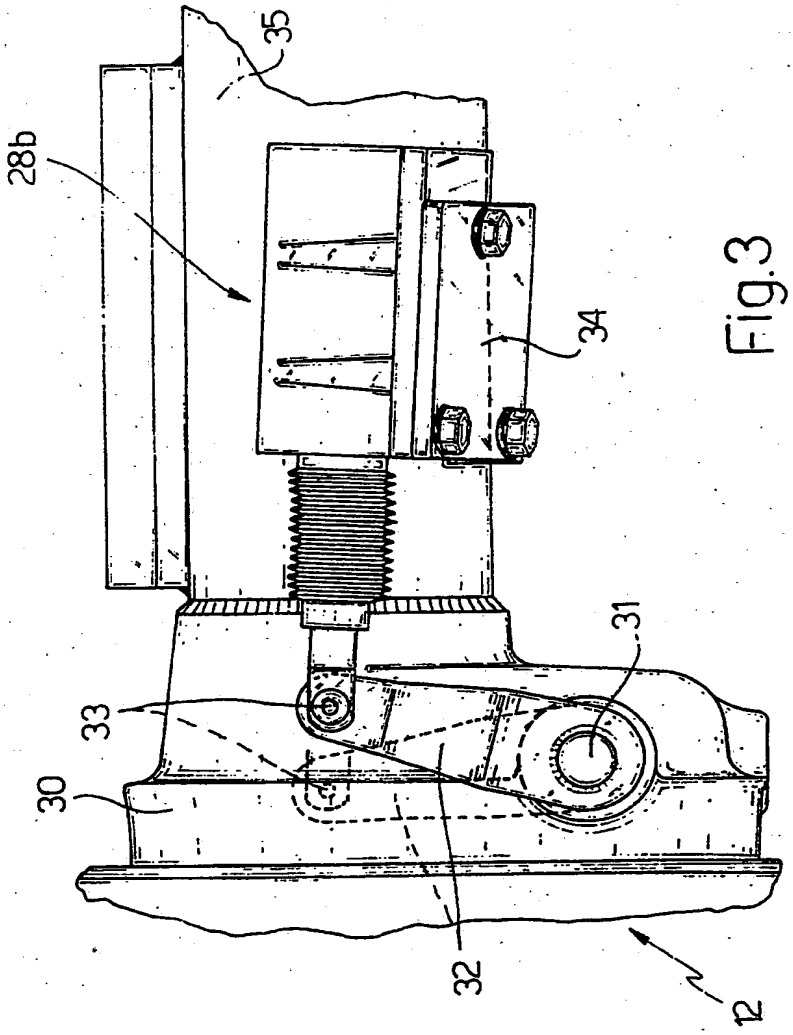


Fig.3

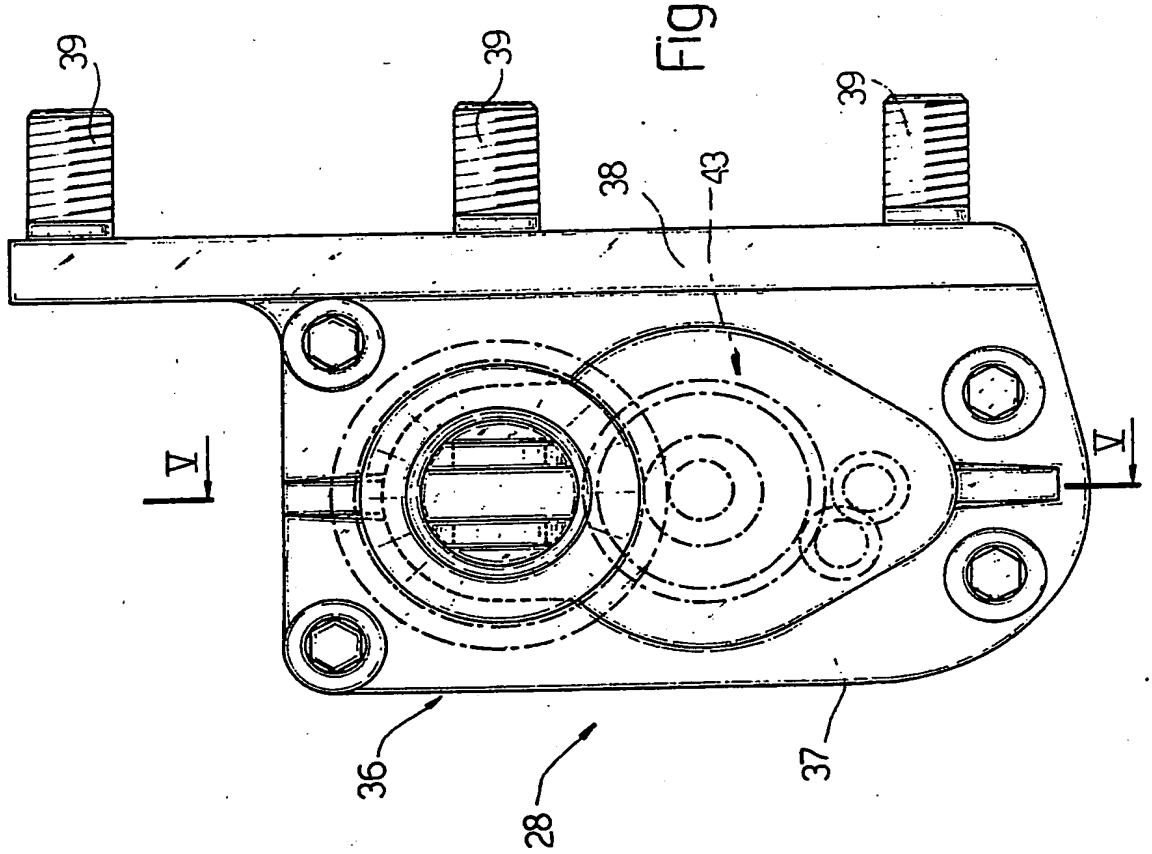


Fig.4

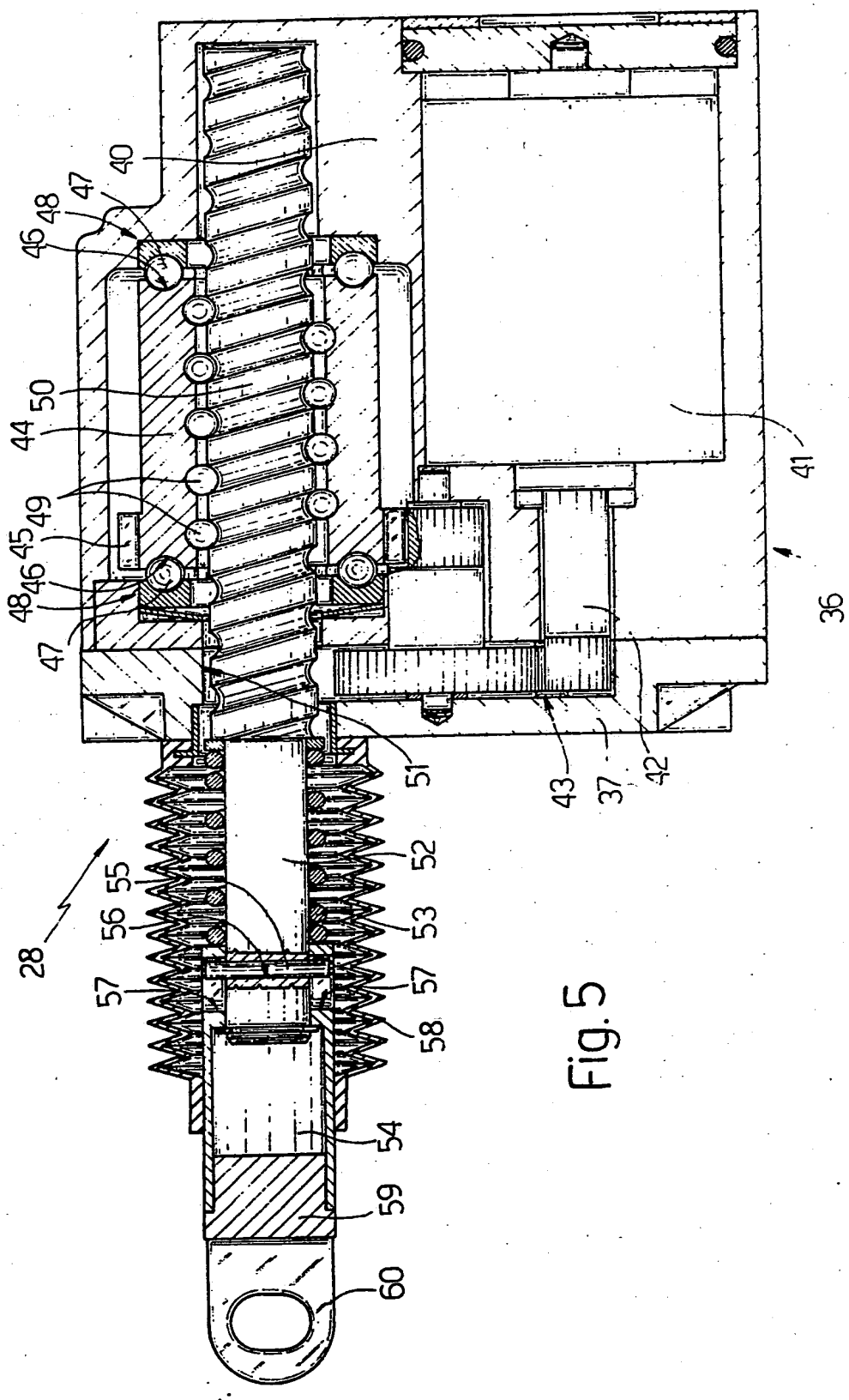

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Fig.5

MECHANICALLY ENGAGED FOUR-WHEEL-DRIVE VEHICLE

The present invention relates to a mechanically engaged four-wheel-drive vehicle.

On vehicles, particularly motor vehicles, featuring an engageable four-wheel drive, the power plant usually comprises an engine-transmission assembly; two drive wheels fitted on to the ends of two axle shafts of a first shaft connected substantially directly to said engine-transmission assembly; two normally-driven wheels; and a drive connecting said driven wheels to said engine-transmission assembly.

Said drive usually comprises two axle shafts of a second shaft, connected in normally idle manner to said driven wheels and to respective outputs of a differential assembly; a propeller shaft connected to an input of said differential assembly; and three disengageable couplings, a first of which is designed to connect the propeller shaft to the engine-transmission assembly, and the other two to connect the driven wheels integral with the respective axle shafts.

On known vehicles of the aforementioned type, each said coupling usually presents a pneumatic control device, usually comprising a vacuum tank designed, by means of solenoid valves, to enable axial distortion of a diaphragm controlling engagement and disengagement of the coupling, and having electronic control circuits for determining the coupling position and operating sequence.

In addition to the relatively high-cost structure of the aforementioned pneumatic control device, diaphragm response also varies according to external pressure and temperature, with the result that, when four-wheel-drive performance is most needed (at high altitude, with a low external temperature), engagement is invariably impaired by the rigidity of the diaphragms (which increases alongside a fall in temperature) and the minimal difference between external pressure and that inside the vacuum tank.

The aim of the present invention is to provide a vehicle featuring an engageable four-wheel drive, designed to overcome the aforementioned drawbacks.

With this aim in view, according to the present invention, there is provided a vehicle featuring an engageable four-wheel drive and comprising an engine-transmission assembly; two normally-driven wheels; and a drive connecting said driven wheels to said engine-transmission assembly; said drive comprising a differential assembly; two axle shafts connected in normally idle manner to said driven wheels and to respective outputs of said differential assembly; a propeller shaft connected

to an input of said differential assembly; three disengageable couplings, of which a first is located between said propeller shaft and said engine-transmission assembly, and the other two between said driven wheels and respective axle shafts; and a control device for each said coupling, designed to operate the same between an engaged and disengaged position; characterised by the fact that each said control device comprises an electromechanical linear actuator having means for activating an axially-mobile output member; a recirculating ball screw-nut screw coupling being provided between said actuating means and said output member.

A non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which :

Fig.1 shows a plan view of the power plant on a vehicle in accordance with the teachings of the present invention;

Fig.2 shows a larger-scale plan view of a first detail in Fig.1;

Fig.3 shows a larger-scale side view of a second detail in Fig.1;

Fig.4 shows a front view of a detail in Fig.s 2 and 3;

Fig.5 shows a section along line V-V in Fig.4.

Number 1 in Fig.1 indicates a motor vehicle having a power plant 2 comprising an engine-transmission assembly 3; two drive wheels 4 fitted on to the ends of respective axle shafts 5 connected to an output of engine-transmission assembly 3; and two normally-driven wheels

6 connectable to the output of engin -transmission assembly 3 via a drive indicated as a whole by 7.

Drive 7 comprises a differential assembly 8 having two outputs connected to two axle shafts 9, and an input connected to a propeller shaft 10. Drive 7 also comprises a first known type of disengageable coupling 11, usually a face gear coupling, located between one end of propeller shaft 10 and the output of engine-transmission assembly 3, and a further two known disengageable couplings 12, also usually face gear couplings, each located between a respective axle shaft 9 and respective wheel 6, which is supported on respective axle shaft 9 in such a manner as to normally turn idly in relation to the same.

As shown in Fig.2, coupling 11 comprises an outer casing 13 with two substantially coaxial outer flanges 14 and 15, and a transverse pin 16 extending through casing 13 and located on the opposite side of flange 15 to that facing flange 14. Rotation of pin 16 one way or the other (anticlockwise in Fig.2) about its own axis and in relation to casing 13, provides in known manner for respectively engaging or disengaging coupling 11. The outer end of pin 16 is fitted to the center portion of a rocker arm 17, a first arm 18 of which presents an end plate 19 cooperating with a push-button 20 of a microswitch 21 supported on a bracket 22 connected to flange 14 via screw 23. A second arm 24 of rocker arm 17 cooperates with a limit stop 25 connected to surface 26 of flange 15 facing pin 16. To surface 26 there is also connected a first arm of a substantially

L-shaped bracket 27, the second arm of which, located outside and substantially parallel with the axis of casing 13, supports a control device or linear actuator 28a connected to arm 18 in the vicinity of plate 19 via pin 29, and designed to turn arm 17 and pin 16 between an engaged position and a disengaged position, contacting limit stop 25, as shown respectively by the continuous and dotted lines in Fig.2.

As shown in Fig.3, each coupling 12 is housed inside a casing 30 located inside respective wheel 6 and having a transverse pin 31 extending through casing 30 and designed, when turned one way or the other (clockwise in Fig.3) in relation to casing 30, to respectively engage or disengage coupling 12 in known manner.

The outer end of pin 31 is fitted on to one end of a lever 32, the other end of which is connected via transverse pin 33 to a control device or linear actuator 28b designed to turn lever 32 and pin 31 between an engaged and disengaged position as shown respectively by the continuous and dotted lines in Fig.3.

Actuator 28b is supported in fixed manner on a bracket 34 integral with a tube 35 protecting respective axle shaft 9 and forming part of the rear shaft of motor vehicle 1.

As shown in Fig.s 4 and 5, each of actuators 28a and 28b, indicated generically by 28, comprises a substantially cup-shaped outer casing 36 closed at one end by cover 37 and having a lateral wall defined by a projecting plate 38 with studs 39 for securing actuator 28 to a support.

An inner wall 40 divides casing 36 into two axial chambers, a first of which houses a reversible electric motor 41 having an output shaft 42 connected to the input of a reduction unit indicated as a whole by 43. The second chamber of casing 36 houses a cylindrical recirculating ball nut screw 44 having external teeth 45 constituting the output gear of reduction unit 43. As shown in Fig.5, the opposite ends of nut screw 44 present two annular grooves 46 constituting the tracks of balls 47 of respective axial thrust bearings 48 connecting nut screw 44 in rotary manner to the inner surface of casing 36 and cover 37. A screw 50 is mounted for rotation, via the interposition of balls 49, through nut screw 44, one end of which screw 50 extends through a hole 51 in cover 37 and is fitted with a rod 52 constituting the output member of actuator 28.

Rod 52 is connected to rocker arm 17 or lever 32 via the interposition of a damping element, for which purpose, the free end of rod 52 is fitted in sliding manner, by means of a helical spring 53 coaxial with rod 52, with a coupling 54, the stroke of which, in relation to rod 52, is determined by a pin 55, the intermediate portion of which engages a diametrical through hole 56 formed through rod 52, and the end portions of which engage, in sliding manner, respective axial slots 57 formed through coupling 54. Coupling 54 is fitted to one end of bellows 58 having its other end connected to cover 37, and is closed at its free end by a cap 59 fitted with a ring 60 engaged by pin 29 or 33.

In actual use, when the four-wheel drive is disengaged,

with rocker arm 17 and levers 32 positioned as shown by the dotted lines in Fig.s 2 and 3, operation by the user of a connecting device (not shown) first provides for activating motor 41 of actuator 28a. Motor 41 turns nut screw 44 so as to axially shift rod 52 from the withdrawn (disengaged) position to the extracted (engaged) position, and so shift rocker arm 17 into the engaged position shown by the continuous line in Fig.2. In this position, plate 19 of rocker arm 17 presses button 20 of microswitch 21, which supplies a known control circuit (not shown) with a signal indicating engagement of coupling 11. Said signal acts as an enabling signal for sequentially operating actuators 28b, which provide for engaging respective couplings 12, and so also driving wheels 6.

The above procedure is performed in reverse for disengagement.

Electromechanical actuators 28 clearly provide, therefore, for substantially eliminating any possibility of engagement being impaired by external pressure and temperature. Moreover, by virtue of reduction unit 43 and screw-nut screw coupling 44-50, which in itself provides for a high reduction ratio, actuators 28 provide for high-power performance while at the same time employing a relatively high-speed, low-cost motor 41.

CLAIMS

1) - A vehicle featuring an engageable four-wheel drive, and comprising an engine-transmisson assembly ; two normally-driven wheels ; and a drive connecting said driven wheels to said engine-transmission assembly ; said drive comprising a differential assembly ; two axle shafts connected in normally idle manner to said driven wheels and to respective outputs of said differential assembly ; a propeller shaft connected to an input of said differential assembly ; three disengageable couplings , of which a first is located between said propeller shaft and said engine-transmission assembly , and the other two between said driven wheels and respective axle shafts ; and a control device for each said coupling , designed to operate the same between an engaged and disengaged position; characterised by the fact that each said control device comprises an electromechanical linear actuator having means for activating an axially-mobile output member ; a recirculating ball screw-nut screw coupling being provided between said actuating means and said output member .

2) - A vehicle as claimed in Claim 1, characterised by the fact that each said control device also comprises a lever element hinged to said output member and fitted to a pin designed, when turned between two distinct angular positions about its own axis, to engage or disengage the respective said coupling.

3) - A vehicle as claimed in Claim 2, characterised by the fact that said output member is connected to the respective said lever element via the interposition of damping means .

4) - A vehicle as claimed in any one of the foregoing Claims, characterised by the fact that the device controlling said first coupling comprises a device for determining said engaged and disengaged positions.

5) - A mechanically engaged four-wheel-drive vehicle, substantially as described and illustrated herein with reference to the accompanying drawings.

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